

II. "On Certain Ternary Alloys. Part III. Alloys of Bismuth, Zinc, and Tin, and of Bismuth, Zinc, and Silver." By C. R. ALDER WRIGHT, D.Sc., F.R.S., Lecturer on Chemistry and Physics in St. Mary's Hospital Medical School, and C. THOMPSON, F.I.C., F.C.S. Received January 24, 1891.

The general methods adopted in carrying out the experiments detailed below were identical with those described in Part II,* the weighed metals being fused together under cyanide of potassium, well intermixed by continued vigorous stirring, and poured into red-hot narrow clay test-tubes, which were then inserted inside thin iron protecting tubes, closed at the lower end, and immersed in a bath of molten lead, maintained at as nearly as possible a constant temperature by means of a series of Bunsen flames playing into the interspace between the cylindrical iron vessel containing the lead and an outer concentric clay jacket. Fluctuations of temperature, to a greater or lesser extent, being unavoidable during long periods of heating, notwithstanding all care, some of the figures ultimately deduced were less concordant than those obtained in the experiments previously described, the mode of separation of a given mass into two different alloys being apparently more affected by temperature variations with mixtures containing bismuth than with corresponding mixtures containing lead instead of bismuth.

Our first experiments were made with the object of determining the mutual solubilities of bismuth and zinc at different temperatures. Matthiessen and v. Bose found ('Roy. Soc. Proc.' vol. 11, p. 430) that melted bismuth could dissolve zinc, forming an alloy containing 12.93 to 16.30 per cent. of zinc (excluding two determinations of 8.65 and 8.80 per cent. respectively, presumably erroneous from some undetected source of error); and that zinc could dissolve bismuth, forming an alloy containing 2.38 to 2.48 per cent. of bismuth; no record of temperature was made in these observations further than that the molten metals were ultimately poured into "a porous cell which had been previously heated to redness in a large crucible filled with sand."

We obtained the following figures, approximately equal weights of bismuth and zinc being melted together and well stirred up, the mixtures being then poured into red-hot narrow clay test-tubes, and heated in the lead-bath for periods of eight hours and upwards.

* 'Roy. Soc. Soc.', vol. 48, p. 25; Part I, *ibid.*, vol. 45, p. 461.

Zinc dissolved by Bismuth.

Temperature range	550—650°.	650—750°.	750—850°.
Percentage of zinc in alloy.....	14·03	14·42	15·27
" " " 	14·05	14·62	15·59
" " " 	—	—	16·19
" " " 	—	—	16·26
Average.....	14·04	14·52	15·83

Bismuth dissolved by Zinc.

Percentage of bismuth in alloy...	2·20	2·24	2·44
" " " 	2·24	2·60	2·60
Average	2·22	2·42	2·52

From these figures it results that the following percentages of zinc and bismuth respectively are dissolved for the mean temperatures 650°, 750°, and 800°.

Zinc dissolved by Bismuth.

Range	550—650°	14·04	Range 650—750°	14·52	Range 750—850°
" 	650—750°	14·52	" 750—850°	15·83	
Approximate } mean temp. } of 650°.... }	Average ..	14·28	Mean temp. of } 750°..... }	15·18	Mean temp. } of 800° } 15·83

Bismuth dissolved by Zinc.

Range	550—650°	2·22	Range 650—750°	2·42	Range 750—850°
" 	650—750°	2·42	" 750—850°	2·52	
Approximate } mean temp. } of 650°.... }	Average ..	2·32	Mean temp. of } 750°..... }	2·47	Mean temp. } of 800° } 2·52

Hence, while the solubility of bismuth in zinc increases between 650° and 800° to an extent only just measurable and barely outside the limits of experimental error, that of zinc in bismuth increases

in a much more marked fashion. The formula Zn_4Bi_7 requires $\text{Zn} = 15.1$, and $\text{Bi} = 84.9$ per cent.

Mixtures of Bismuth, Zinc, and Tin.

Two series of experiments were made, one at a temperature ranging between 600° and 700° , and averaging near to 650° ; the other ranging between 700° and 800° , and averaging near to 750° . The results indicate that in presence of tin the solubility of zinc in bismuth and that of bismuth in zinc are both materially increased by increment of temperature. A few experiments at a somewhat higher temperature, averaging near 800° , were also made, the results of which indicated a notable further increment in solubility; but, as considerable difficulty was experienced in getting even moderately concordant figures at this higher temperature, these observations were not carried far enough to enable average curves to be deduced. In every case the mixture of metals employed contained equal quantities of bismuth and zinc with varying proportions of tin; as in the case of the lead-zinc-tin alloys previously described, the effect of volatilisation and oxidation caused a small decrement in the proportion of zinc present in the compound ingots ultimately obtained relatively to the other two metals contained therein, especially in the experiments at the higher temperatures.

In analysing the alloys prepared, we found that the method of analysis used for lead-zinc-tin alloys could not be adopted without modification, because the stannic oxide formed by the action of nitric acid on the alloys retained variable amounts of bismuth in such a condition as not to be removed by copious washing with dilute nitric acid, or even by boiling therewith.* In some instances we weighed the crude stannic oxide retaining bismuth, and then fused it with sodium carbonate and sulphur, whereby sodium sulphostannate was formed, soluble in water, and bismuth sulphide insoluble therein. By precipitating the stannic sulphide by means of hydrochloric acid from the aqueous solution, and cautiously roasting it, the corrected weight of stannic oxide was obtained; this we found always concorded sensibly with the weight deduced by converting the undissolved bismuth sulphide into oxide (by dissolving in nitric acid, precipitating boiling with ammonium carbonate, and igniting the precipitate), and subtracting the weight of this from that of the crude stannic oxide. In other cases, we dissolved the alloy in hydrochloric acid containing a little nitric acid, diluted and treated with sulphuretted hydrogen, separating the tin

* It is noteworthy that no trace of lead appears to be thus retained by stannic oxide when alloys containing tin and lead are treated with nitric acid; on the other hand, when alloys containing antimony and lead are similarly treated, the undissolved antimony oxide retains a notable amount of lead, just as stannic oxide retains bismuth.

and bismuth thus precipitated with ammonium sulphide. Check experiments made by both methods yielded sensibly the same tin percentages. In order to determine the zinc after removal of bismuth and tin, we first precipitated it as sulphide, then dissolved in hydrochloric acid, and precipitated as carbonate, finally igniting and weighing as oxide; this method of treatment being adopted to prevent lime, &c., derived from the vessels used being weighed with the zinc, as would have been the case had the precipitation as sulphide been omitted. Any traces of oxide of iron contained in the zinc oxide were subsequently estimated and subtracted.

The following figures were derived from the examination of twenty-one compound ingots, the percentages being reckoned upon the sum of the weights of tin, bismuth, and zinc found as 100. With some of the lighter alloys, where zinc was the main constituent, only the tin and bismuth were determined, and the zinc taken by difference.

Series I. Temperature 600—700°.

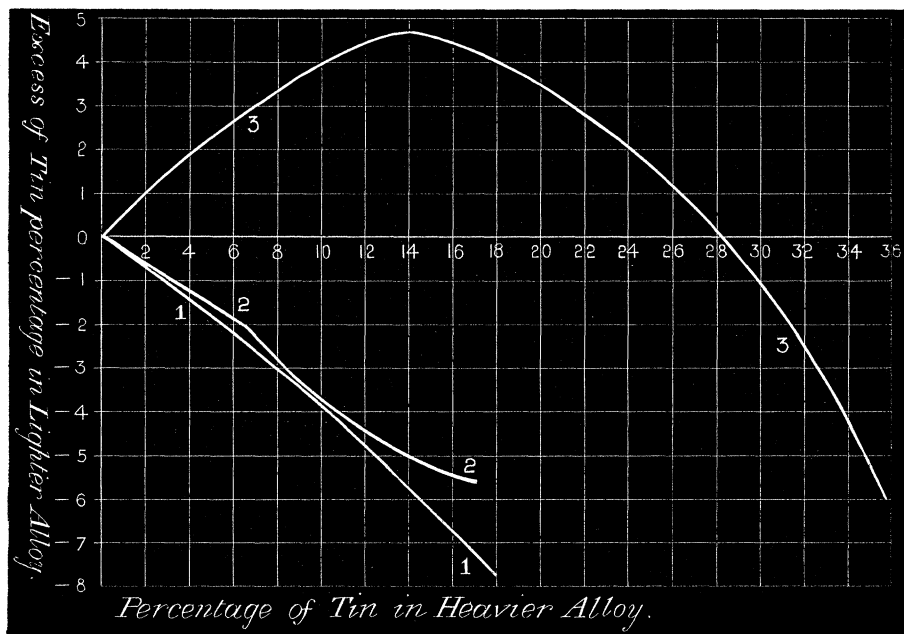
Percentage of tin in mixture before fusion.	Heavier alloy.			Lighter alloy.			Excess of tin percentage in lighter alloy over that in heavier.
	Tin.	Bismuth.	Zinc.	Tin.	Bismuth.	Zinc.	
0	0	85·72	14·28	0	1·32	97·68	0
2·5	3·23	80·27	16·50	1·98	3·45	94·57	-1·25
5·0	6·35	75·82	17·83	3·97	4·21	91·82	-2·38
8·3	10·38	70·52	19·10	6·35	5·53	88·12	-4·03
13·2	14·35	62·24	23·41	8·50	8·04	83·46	-5·85
15·9	18·01	56·10	25·89	10·24	10·90	78·86	-7·77
18·7	20·50	47·02	32·48				

Series II. Temperature 700—800°.

Percentage of tin in mixture before fusion.	Heavier alloy.			Lighter alloy.			Excess of tin percentage in lighter alloy over that in heavier.
	Tin.	Bismuth.	Zinc.	Tin.	Bismuth.	Zinc.	
0	0	84·82	15·18	0	2·47	97·53	0
5·3	6·29	76·20	17·51	4·24	5·24	90·52	-2·05
7·1	8·81	72·34	18·85	5·40	6·08	88·52	-3·41
8·8	10·35	67·71	21·94	6·29	7·35	86·36	-4·06
12·3	14·72	59·99	25·29	9·60	9·65	80·75	-5·12
15·3	16·87	54·03	29·10	11·57	12·62	75·81	-5·30

On plotting these figures as curves it is noticeable that, whilst the distribution of the tin between the heavier and lighter alloys formed is only slightly different according as the temperature is 650° or 750° , in each case the curve is of an entirely different character from that deducible from the previous experiments with lead, zinc, and tin. Instead of rising above the base line to a maximum and then falling again, ultimately crossing the base line and passing below it, each curve *lies completely below the base line*. Curves Nos. 1 and 2, fig. 1,

FIG. 1.

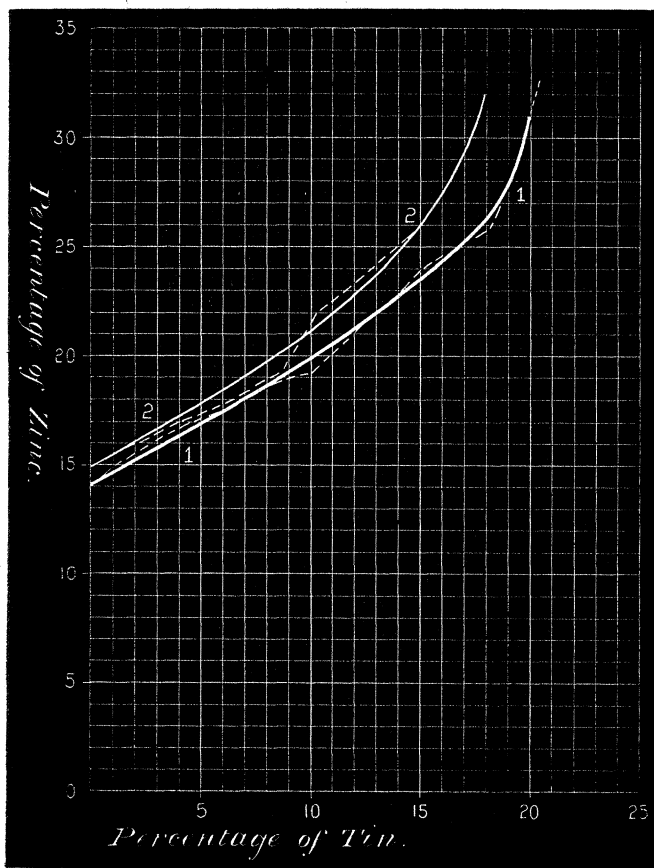


respectively represent the above values at 650° and 750° ; whilst No. 3 represents the corresponding curve obtained (Part I) with equal proportions of lead and zinc in the original mixtures at near 650° ; in each case the abscissæ are the percentages of tin in the heavier alloys, whilst the ordinates are the excesses of the tin percentages in the lighter alloys over the corresponding percentages in the heavier ones.

On the other hand, on plotting the curves representing the solubility of zinc in bismuth-tin (percentages of tin in heavier alloys as abscissæ, and those of zinc as ordinates), and of bismuth in zinc-tin (percentages of tin in lighter alloys as abscissæ, and those of bismuth as ordinates), it is obvious that the solubility increases in each case

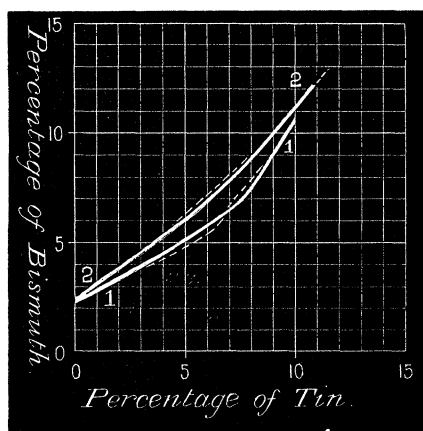
with the temperature, and that the amount of bismuth dissolved by zinc, or *vice versâ*, regularly increases as the amount of tin present increases, just as in the case of the corresponding alloys containing lead instead of bismuth. Figs. 2 and 3 represent the solubility curves, the

FIG. 2.



curves marked 1 and 2 respectively indicating the values obtained at 650° and 750°; the dotted lines connect the actual points of observation, whilst the continuous lines represent the smoothed mean curves thence deduced. The following solubility tables are derived from these mean curves.

FIG. 3.



Solubility of Zinc in Bismuth-Tin.

At near 650°.			At near 750°.	
Percentage of tin.	Percentage of zinc.	Difference for 1 per cent.	Percentage of zinc.	Difference for 1 per cent.
0	14.28	—	15.18	—
2	15.20	0.46	16.10	0.46
4	16.20	0.50	17.10	0.50
6	17.30	0.55	18.20	0.55
8	18.50	0.60	19.50	0.65
10	19.80	0.65	21.00	0.75
12	21.20	0.70	22.80	0.90
14	22.70	0.75	24.90	1.05
16	24.30	0.80	27.50	1.30
17	25.15	0.85	29.40	1.90
18	26.20	1.05	32.00	2.60
19	28.10	1.90	—	—
20	31.00	2.90	—	—

Solubility of Bismuth in Zinc-Tin.

At near 650°.			At near 750°.	
Percentage of tin.	Percentage of bismuth.	Difference for 1 per cent.	Percentage of bismuth.	Difference for 1 per cent.
0	2·32	—	2·47	—
1	2·80	0·48	3·05	0·58
2	3·30	0·50	3·70	0·65
3	3·80	0·50	4·40	0·70
4	4·30	0·50	5·15	0·75
5	4·80	0·50	5·95	0·80
6	5·35	0·55	6·80	0·85
7	6·10	0·75	7·70	0·90
8	7·20	1·10	8·65	0·95
9	8·70	1·50	9·70	1·05
10	10·70	2·00	10·90	1·20
11	—	—	12·20	1·30

On comparing these mean curves with those described in Parts I and II, obtained with lead-zinc-tin alloys, it is evident that the solubility of zinc in bismuth is always greater than that in lead, whether tin be absent or present to a given extent in each case; and that, in the latter case, the rate of increment in the solubility of zinc in bismuth as the proportion of tin present increases is more rapid than the corresponding rate of increment in the solubility of zinc in lead. Precisely similar remarks apply to the solubility of bismuth in zinc.

Mixtures of Bismuth, Zinc, and Silver.

It has already been mentioned in Part II that mixtures of bismuth, zinc, and silver show the same remarkable behaviour as analogous mixtures of lead, zinc, and silver, leading to the conclusion that two definite compounds of zinc and silver are formed under appropriate conditions, indicated respectively by the formulæ AgZn_5 and Ag_4Zn_5 ; of which the first is characterised by being capable of dissolving more lead (or bismuth) than can either pure zinc or the second compound, and of being more soluble in lead (or bismuth) than either of these; also of being somewhat unstable, so that when a solution of lead (or bismuth) in AgZn_5 is kept molten for a long time it breaks up forming zinc and Ag_4Zn_5 , which being unable to dissolve all the lead originally present, causes the separation of lead from the liquid metal as a heavier alloy containing a little zinc and silver in solution. The second compound Ag_4Zn_5 is characterised by the peculiar red colour assumed by a recently cut or filed surface exposed to the air for awhile, and by

the circumstance that it is less soluble in lead (or bismuth), relatively to the zinc present, than either pure zinc or a mixture of zinc and silver in any other proportion.

Three series of experiments were made exactly corresponding with those previously described with lead-zinc-silver alloys in Part II; in each case the temperature was as near 750° as could be managed, ranging between 700° and 800°. The analysis of the alloys was made by dissolving in nitric acid, diluting, precipitating silver by hydrochloric acid, and washing the precipitate by decantation with hot dilute hydrochloric acid, in case any bismuth oxychloride might have separated. The filtrate was evaporated to a small bulk and treated with water, and the filtrate from the bismuth oxychloride formed treated with sulphuretted hydrogen; the bismuth in the sulphide and oxychloride thus obtained was determined by converting the joint precipitates into oxide by dissolving in nitric acid, precipitating boiling with ammonium carbonate, and igniting. The zinc was determined as in the former alloys, and corrected for small quantities of iron derived from the crucibles, &c.

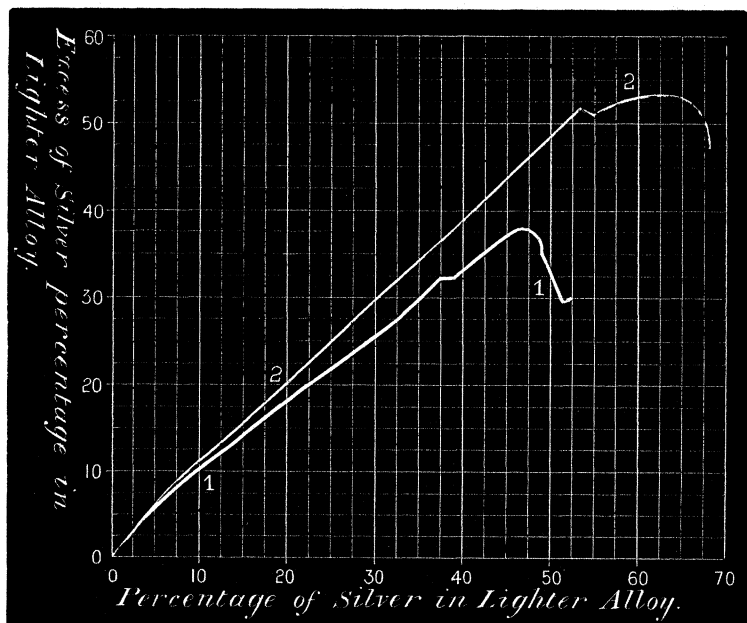
Series I.—Time of fusion, 8 hours. Temperature 700—800°.

Percentage of silver in mixture before fusion.	Heavier alloy.			Lighter alloy.			Excess of silver percentage in lighter alloy over that in heavier.
	Silver.	Bismuth.	Zinc.	Silver.	Bismuth.	Zinc.	
0	0	84·82	15·18	0	2·47	97·53	0
2	0·04	85·05	14·91	3·83	4·17	92·00	3·79
4	0·20	84·39	15·41	10·44	5·71	83·85	10·24
6·25	0·96	79·09	19·65	14·38	7·16	78·46	13·42
8·75	2·29	74·09	23·62	17·19	10·60	72·21	14·90
12·5	3·32	76·48	20·20	22·36	13·39	64·25	19·04
14	3·49	77·95	18·56	26·42	11·04	62·54	22·93
15·5	4·56	74·92	20·52	30·30	6·40	63·30	25·74
18	4·95	76·10	18·95	34·18	5·63	60·19	29·23
21	5·08	79·28	15·64	37·06	5·34	57·60	31·98
25	6·84	77·24	15·92	38·80	5·93	55·27	31·96
31	8·98	77·99	13·03	46·31	8·67	45·02	37·33
33	12·71	76·19	11·10	47·94	10·05	42·01	35·23
36	14·39	75·24	10·37	48·50	10·50	41·00	34·11
38	22·96	62·72	14·32	51·34	14·34	34·32	28·38
39·5	23·10	61·30	15·60	51·78	15·41	32·81	28·68
40·5	29·27	53·08	17·65	—	—	—	—
45	39·90	41·03	19·07	—	—	—	—

The above figures were derived from a series of twenty-eight compound ingots, each prepared from equal weights of zinc and bismuth with varying proportions of silver. They show almost exactly the

same peculiarities as the corresponding series obtained with lead, zinc, and silver described in Part II; thus the silver-distribution curve is of sensibly the same character, the excess of silver in the lighter alloy over that in the heavier being at first extremely great, but later on lessening, until a maximum elevation of the curve above the base line is attained, after which the curve again descends. Curve No. 1, fig. 4, indicates this, No. 2 being the corresponding curve from the

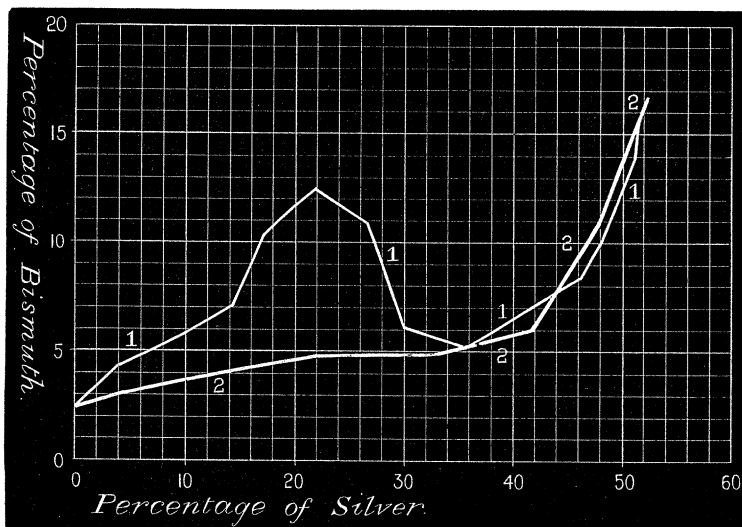
FIG. 4.



lead-zinc-silver alloys (Part II), the abscissæ in each being the percentages of silver in the *lighter* alloys, and the ordinates the excesses of silver percentage in the lighter alloys over those in the heavier ones. Similarly, the curve traced out by plotting the silver and bismuth percentages in the lighter alloys as abscissæ and ordinates respectively (No. 1, fig. 5) exhibits the same feature of rapid rise to a maximum, subsequent fall to a minimum but little above the starting level, and later continuous rise. The position of the first maximum, moreover, is close to that indicating the relationship AgZn_5 , just as with the former alloys.

Silver.	Zinc.	Ratio of zinc to silver.
22.36	64.25	1 to 0.348
Calculated for AgZn_5		1 to 0.332

FIG. 5.



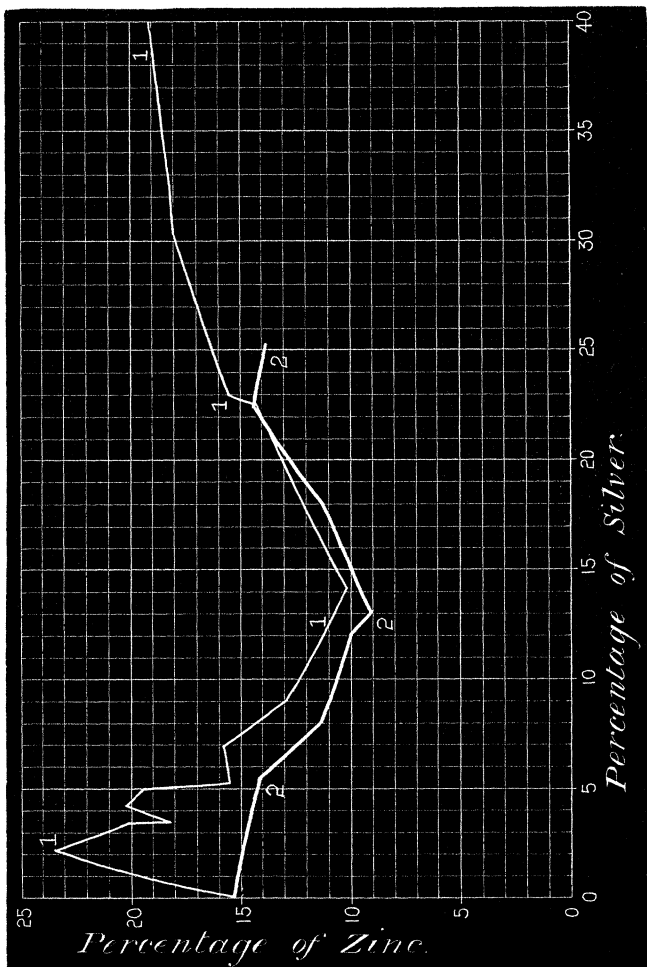
Further, those alloys where the silver and zinc present were approximately in the proportions denoted by Ag_4Zn_5 showed the same marked reddish hue on exposure to the air for a short time, after filing bright, as was observed with the analogous lead-zinc-silver alloys; thus the two alloys containing the following percentages showed it strongly—

Silver.	Bismuth.	Zinc.	Ratio of zinc to silver.
47.94	10.05	42.01	1.14
51.34	14.34	34.32	1.49
Mean.....			1.315
Calculated for Ag_4Zn_5			1.33

as also did some others, the compositions of which lay between these limits, which correspond respectively with 84 per cent. of Ag_4Zn_5 with a little excess of zinc and some bismuth, and with 80 per cent. of Ag_4Zn_5 with excess of silver and some bismuth. On the other hand, alloys containing somewhat larger excesses of silver or zinc showed only a much paler tint, whilst little or no coloration was visible with alloys where the percentage of Ag_4Zn_5 fell below about 65 per cent. We prepared some binary alloys of silver and zinc consisting mainly of Ag_4Zn_5 , with but small excess of either silver or zinc; these showed the coloration strongly.

Again, the curve obtained by plotting the silver and zinc percentages in the heavier alloys as abscissæ and ordinates respectively exhibits (No. 1, fig. 6), first, a rapid rise in the quantity of zinc pre-

FIG. 6.



sent, followed by a fall to such an extent that the zinc present, reckoned per unit of bismuth, diminishes down again to an amount considerably below that present in the binary bismuth-zinc alloy containing no silver; a minimum of zinc is finally attained, after which the zinc present relatively to the bismuth rises continuously.

Silver.	Bismuth.	Zinc.	Zinc per unit of bismuth.
0	84·82	15·18	0·179
2·29	74·09	23·62 (maximum)	0·319
4·95	76·10	18·95	0·249
6·84	77·24	15·92	0·206
8·98	77·99	13·03	0·167
12·71	76·19	11·10	0·145
14·39	75·24	10·37 (minimum)	0·138
22·96	63·72	14·32	0·225
29·77	53·08	17·65	0·332
39·90	41·03	19·07	0·465

This reduction of zinc to a minimum is far more strongly marked than in the case of the lead-zinc-silver alloys; the point where it occurs is not far from that where the silver and zinc present are in the ratio indicated by the formula Ag_4Zn_5 .

Silver.	Zinc.	Ratio of zinc to silver.
14·39	10·37	1 to 1·39
Calculated for Ag_4Zn_5 1 to 1·33		

Whence it may be concluded that, whereas AgZn_5 is much more soluble in fused bismuth than pure zinc (relatively to the zinc present in each case), the same is not the case with the compound Ag_4Zn_5 , which dissolves in bismuth to a much less extent than would zinc alone in the absence of silver.

Series II was prepared in precisely the same way as the corresponding series with the lead-silver-zinc alloys; *i.e.*, mixtures of the three metals were made and fused for eight hours as in Series I; the compound ingots thus obtained were cut in two so as to separate from one another the lighter and heavier alloys thus formed, and the former parts separately fused at the same temperature (700—800°) for

Series II.—Limiting Composition of Lighter Alloys.

Silver.	Bismuth.	Zinc.
3·93	2·95	93·12
13·72	4·15	82·13
21·24	4·83	73·93
33·27	4·89	61·84
37·50	5·34	57·16
41·43	5·90	52·67
48·02	11·12	40·86
52·01	16·47	31·52

another eight hours. In this way a further separation was brought about in the case of the alloys prepared with smaller proportions of silver, but no material alteration in the case of those made with larger proportions, just as with the lead-silver-zinc alloys. On plotting the results, a curve was obtained (No. 2, fig. 5) from which the first maximum, at approximately the point representing the compound AgZn_5 , had completely disappeared, as had also the subsequent fall, the curve exhibiting a progressive rise from beginning to end.

Series III was similarly made with the heavier alloys thus separated from the lighter ones; the results, when plotted (curve No. 2, fig. 6), showed that the abnormally large percentages of zinc observed in the earlier part of the series had disappeared, whilst the diminution in amount of zinc dissolved relatively to the bismuth present down to a minimum and subsequent rise again was still well marked, the position of the minimum corresponding, as before, with a ratio of zinc to silver not far from that indicated by the formula Ag_4Zn_5 .

Series III.—Limiting Composition of Heavier Alloys.

Silver.	Bismuth.	Zinc.	Zinc per unit of bismuth.
0	84·82	15·18	0·179
5·42	80·62	13·96	0·173
7·65	80·70	11·65	0·144
11·71	78·00	10·29	0·132
13·14	77·85	9·01	0·116 (minimum)
17·98	71·00	11·02	0·155
22·96	62·70	14·34	0·228
25·11	61·39	13·50	0·220

Position of minimum :—

Silver.	Zinc.	Ratio of zinc to silver.
13·14	9·01	1 to 1·45
Calculated for Ag_4Zn_5		1 to 1·33
,, ,, AgZn		1 to 1·66

The following tables represent the mean solubility curves deduced from all the preceding results, omitting the earlier alloys in Series I, where, owing to the presence of undecomposed AgZn_5 , excess of lead was present in the lighter alloys, and excess of zinc in the heavier ones.

Solubility of zinc in bismuth-silver.			Solubility of bismuth in zinc-silver.		
Percentage of silver.	Percentage of zinc.	Difference for 1 per cent.	Percentage of silver.	Percentage of bismuth.	Difference for 1 per cent.
0	15·18	—	0	2·47	—
1	14·70	—0·48	5	2·82	0·07
2	14·20	—0·5	10	3·17	0·07
5	12·70	—0·5	15	3·52	0·07
6	12·25	—0·45	20	3·87	0·07
11	10·00	—0·45	25	4·27	0·08
12	9·65	—0·35	30	4·67	0·08
13	9·50	—0·15	35	5·07	0·08
14	9·50	0	36	5·15	0·08
15	9·65	+0·15	37	5·23	0·08
16	10·00	+0·35	38	5·40	0·17
17	10·50	+0·5	39	5·70	0·30
18	11·20	+0·7	40	6·10	0·40
19	12·00	+0·8	41	6·50	0·40
21	13·60	+0·8	42	7·00	0·50
22	14·30	+0·7	43	7·50	0·50
23	14·95	+0·65	44	8·00	0·50
24	15·50	+0·55	45	8·60	0·60
25	16·00	+0·5	46	9·20	0·60
26	16·40	+0·4	47	9·90	0·70
27	16·80	+0·4	48	10·60	0·70
28	17·10	+0·3	49	11·40	0·80
30	17·70	+0·3	50	12·30	0·90
31	17·90	+0·2	51	13·70	1·40
32	18·10	+0·2	52	16·30	2·60
33	18·25	+0·15			
36	18·70	+0·15			
37	18·80	+0·1			
40	19·10	+0·1			

On comparing together the relative effects on the solubility of bismuth in zinc and of zinc in bismuth produced by the simultaneous presence of tin or of silver the same general result is deduced as in the case of lead-silver-zinc and lead-tin-zinc alloys, viz., that in each instance the solubility is considerably more increased by the presence of a given proportion of tin than by that of the same amount of silver. If 100 parts of zinc can take up m parts of bismuth in presence of x parts of tin (or silver), and if 100 parts of bismuth can take up n parts of zinc in presence of x parts of tin (or silver), then the following tables give the correlated values of m , n , and x , these values being minima in the case of alloys containing silver, i.e., being deduced from those experiments where the influence of the presence of the compound AgZn_5 in increasing solubility was eliminated.

<i>x.</i>	Zinc dissolved by 100 parts of bismuth in presence of <i>x</i> parts of tin (or silver).			Bismuth dissolved by 100 parts of zinc in presence of <i>x</i> parts of tin (or silver).		
	Tin at 650°.	Tin at 750°.	Silver at 750°.	Tin at 650°.	Tin at 750°.	Silver at 750°.
	<i>n.</i> Diff.	<i>n.</i> Diff.	<i>n.</i> Diff.	<i>m.</i> Diff.	<i>m.</i> Diff.	<i>m.</i> Diff.
0	16·8 —	17·9 —	17·9 —	2·37 —	2·53 —	2·53 —
2·5	18·5 1·7	19·6 1·7	16·8 -1·1	3·70 1·33	4·30 1·77	2·75 0·22
5	20·3 1·8	21·4 1·8	15·8 -1·0	5·20 1·50	6·20 1·90	3·00 0·25
7·5	22·3 2·0	23·5 2·1	14·9 -0·9	7·00 1·80	8·40 2·20	3·25 0·25
10	24·4 2·1	26·0 2·5	14·0 -0·9	9·50 2·50	10·80 2·40	3·50 0·25
12·5	26·6 2·2	28·5 2·5	13·2 -0·8	13·40 3·90	13·70 2·90	3·75 0·25
15	28·9 2·3	31·1 2·6	12·6 -0·4		17·00 3·30	4·00 0·25
17·5	31·3 2·4	34·0 2·9	12·3 -0·3			4·25 0·25
20	33·7 2·4	37·2 3·2	12·8 +0·5			4·50 0·25
22·5	36·3 2·6	41·2 4·0	13·8 +1·0			4·75 0·25
25	39·1 2·8	46·2 5·0	15·3 +1·5			5·00 0·25
27·5	42·0 2·9	52·3 6·1	17·2 +1·9			5·25 0·25
30	45·0 3·0		19·3 +2·1			5·50 0·25
35	52·1 7·1		22·8 +3·5			6·00 0·50
40	61·8 9·7		25·8 +3·0			6·50 0·50
50			30·7 +4·9			7·60 1·10
60			34·7 +4·0			8·90 1·30
70			38·2 +3·5			10·50 1·60
80			41·4 +3·2			13·00 2·50
90			44·5 +3·1			16·10 3·10
100			47·5 +3·0			19·60 3·50

The curves indicated by the continuous lines in figs. 7 and 8 represent these numbers, the dotted lines representing the analogous curves described in Part II, obtained with lead-zinc-tin and lead-zinc-silver alloys. In fig. 7, curve No. 1 indicates the amounts of zinc dissolved at 650° by 100 parts of bismuth in presence of *x* parts of tin, whilst No. 2 represents the corresponding amounts dissolved at the same temperature by lead. Nos. 3 and 4 similarly represent the amounts of zinc dissolved at 750° by bismuth and at 800° by lead respectively. Nos. 5 and 6 indicate the amounts of zinc dissolved in presence of *x* parts of silver by 100 parts of bismuth at 750° and of lead at 800° respectively.

In fig. 8, curves Nos. 1 and 2 respectively represent the amounts of bismuth and lead dissolved by 100 parts of zinc in presence of *x* parts of tin at 650°. Nos. 3 and 4 represent similarly the bismuth dissolved at 750° and the lead at 800° respectively. Nos. 5 and 6 indicate the bismuth dissolved at 750° and the lead at 800° in presence of *x* parts of silver.

Fig. 7.

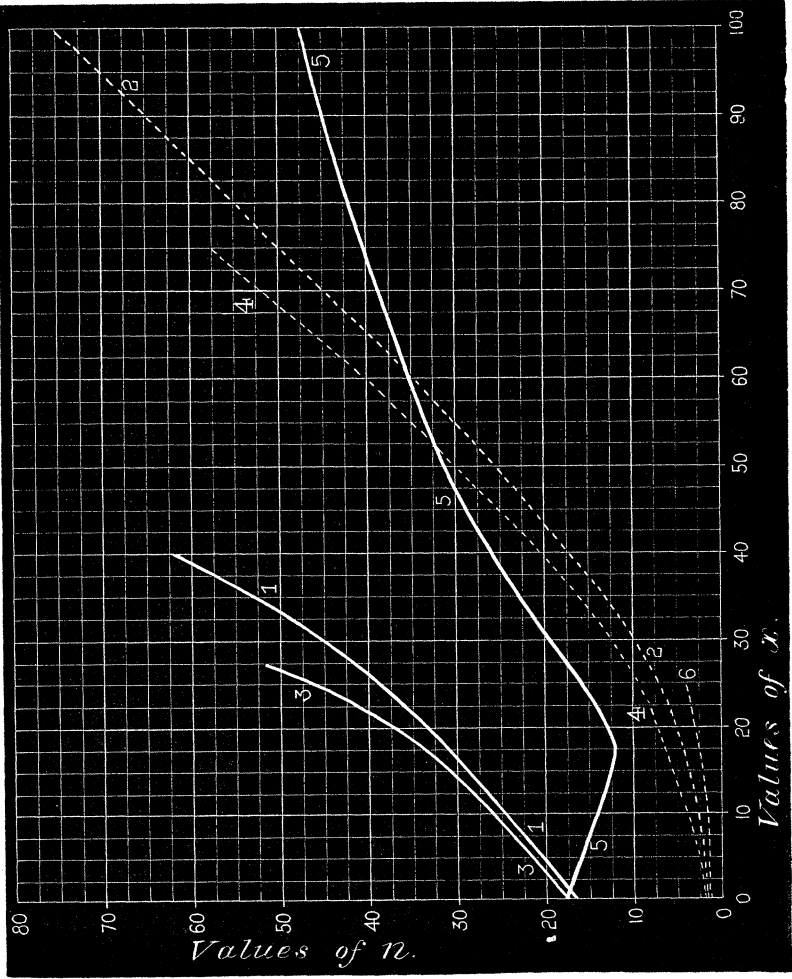


FIG. 8.

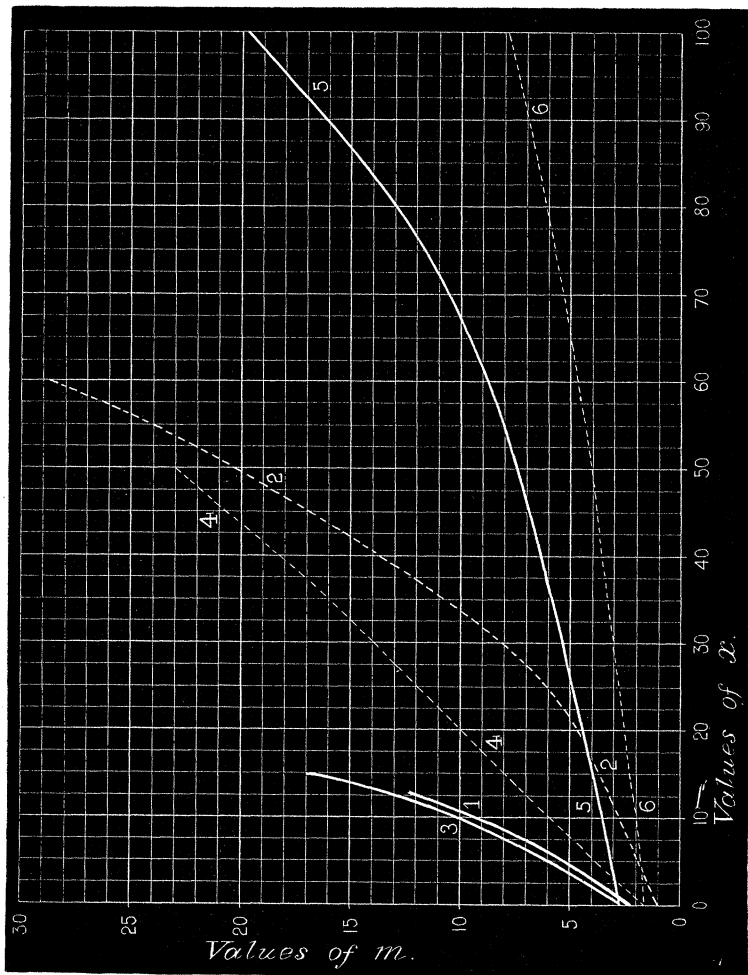


FIG. 1.

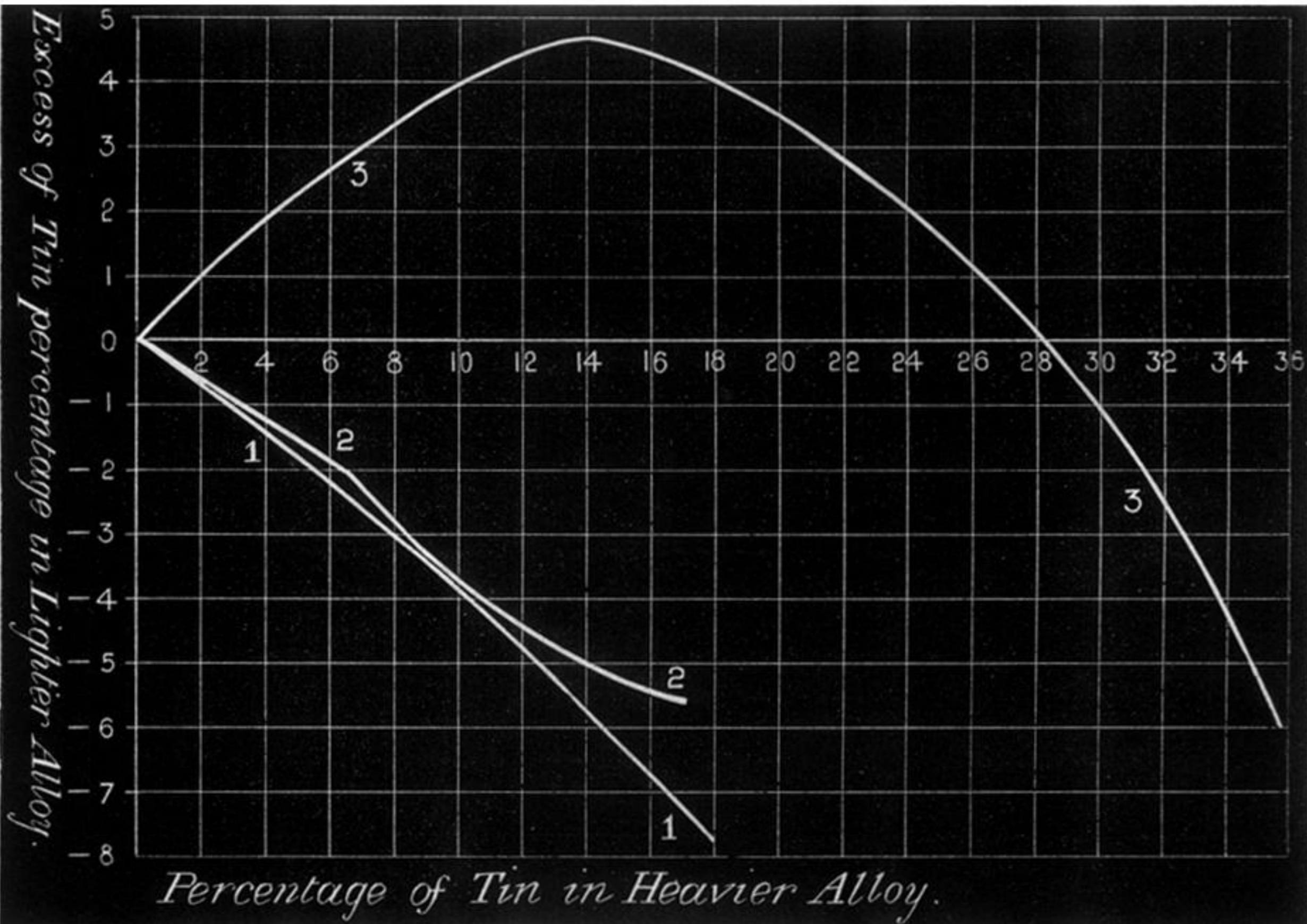


FIG. 2.

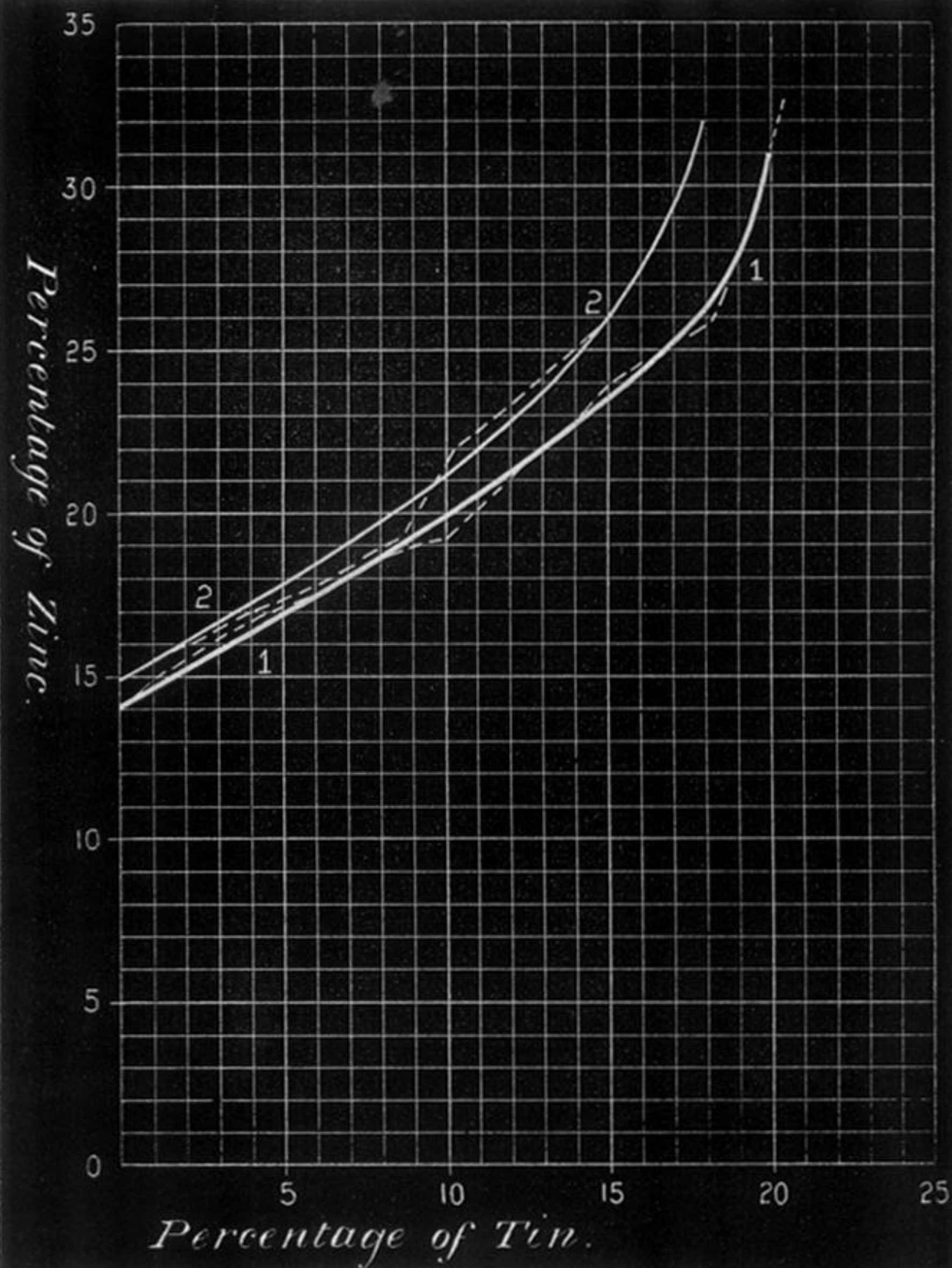


FIG. 3.

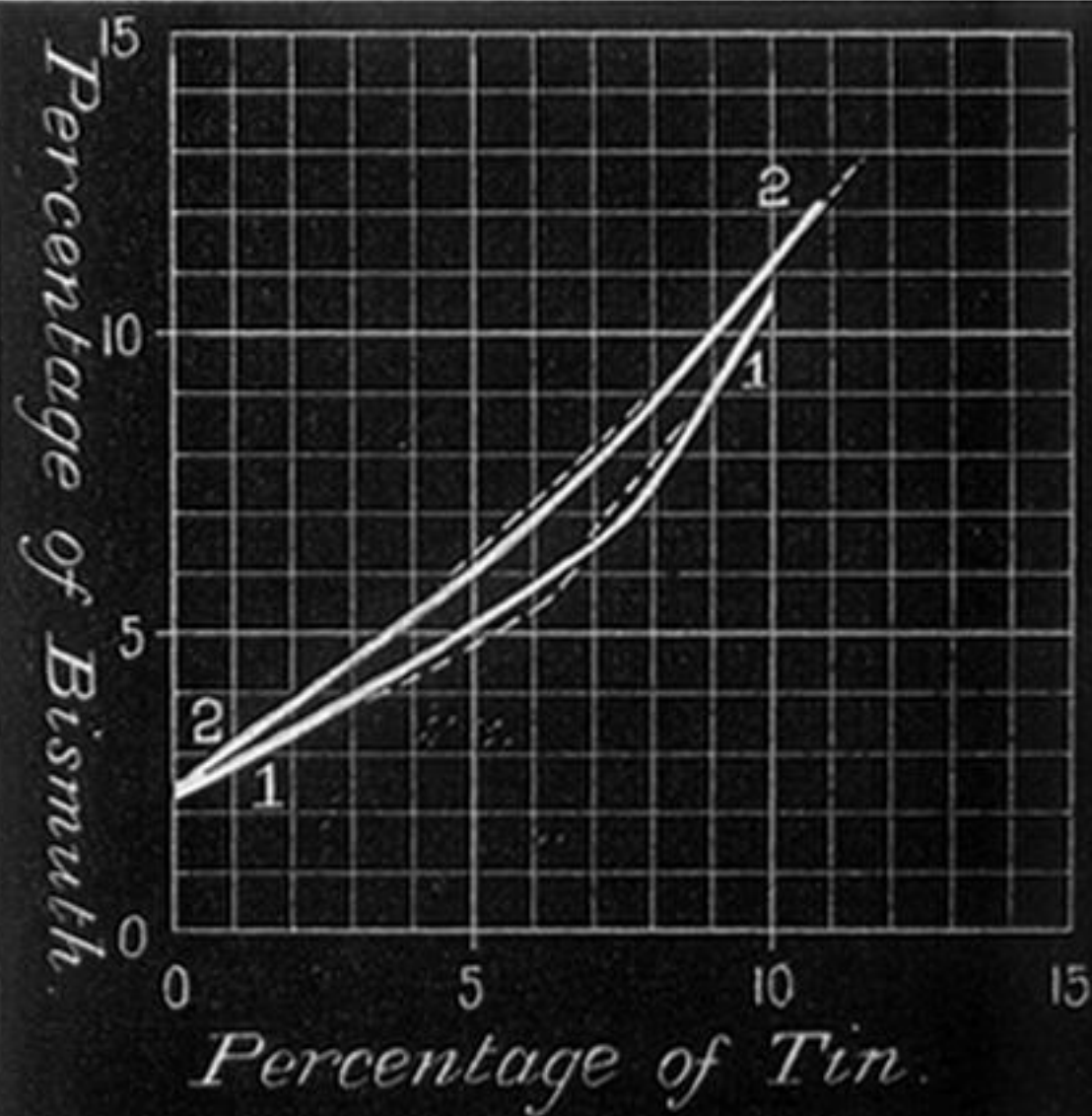


FIG. 4.

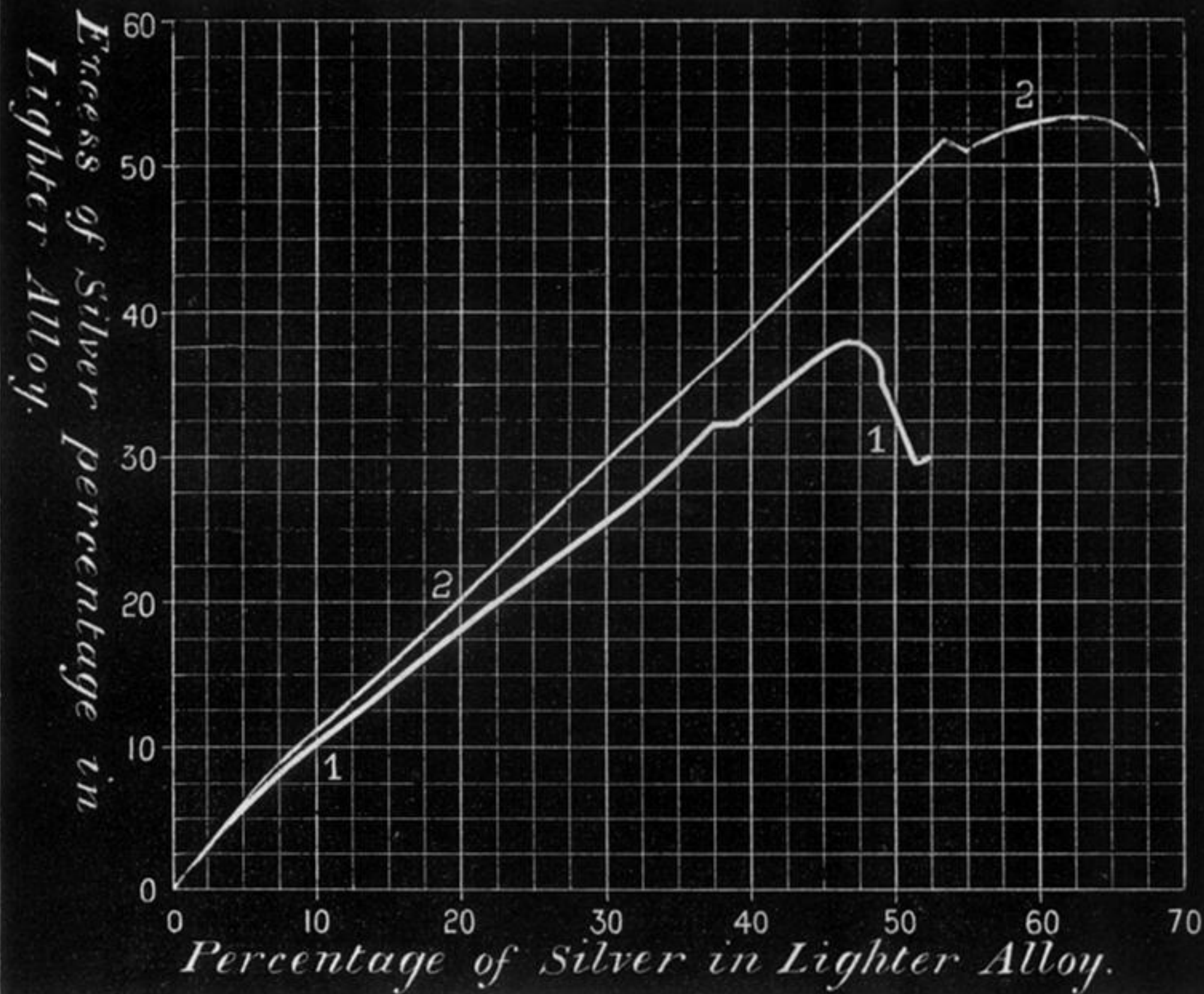


FIG. 5.

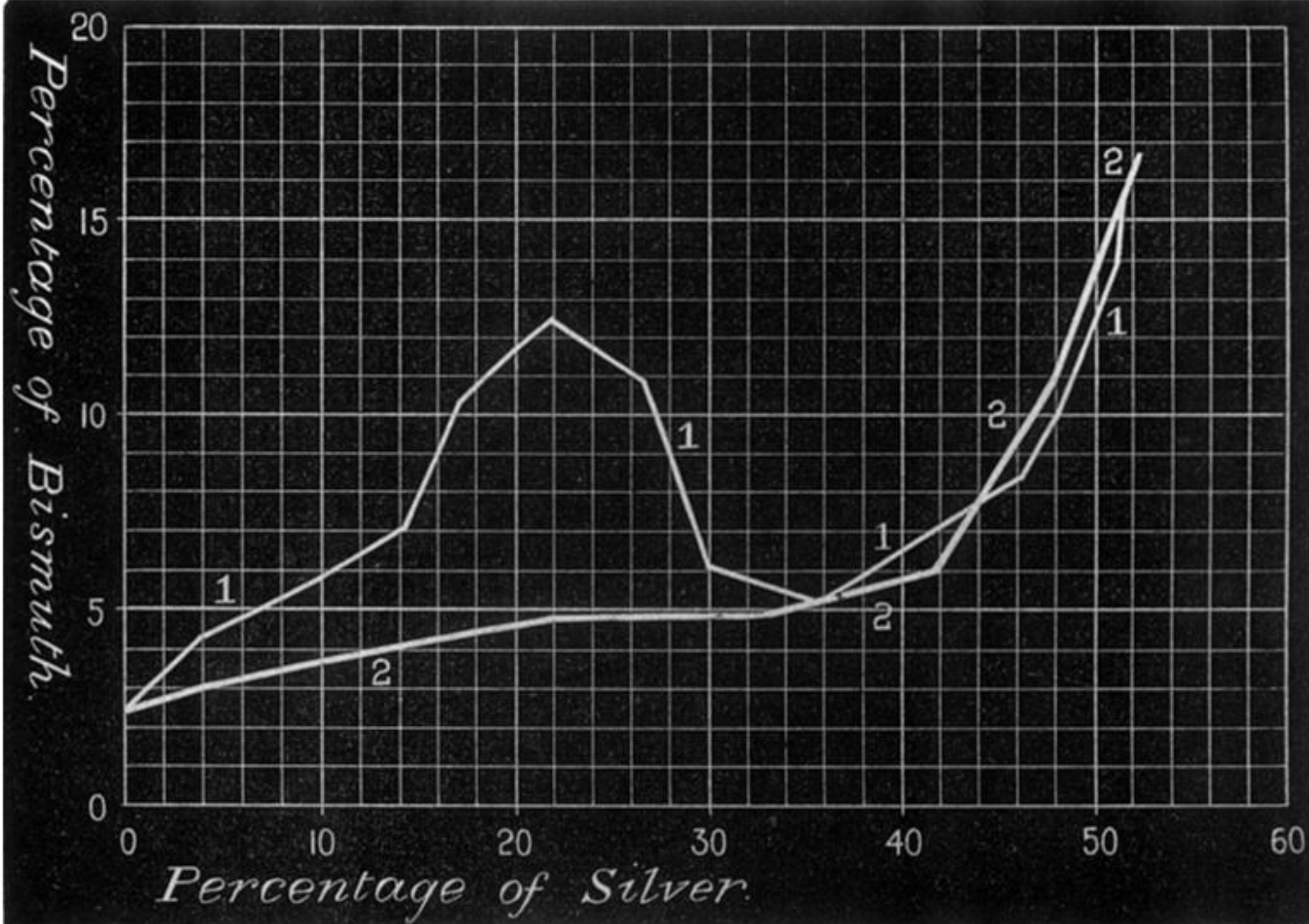


FIG. 6.

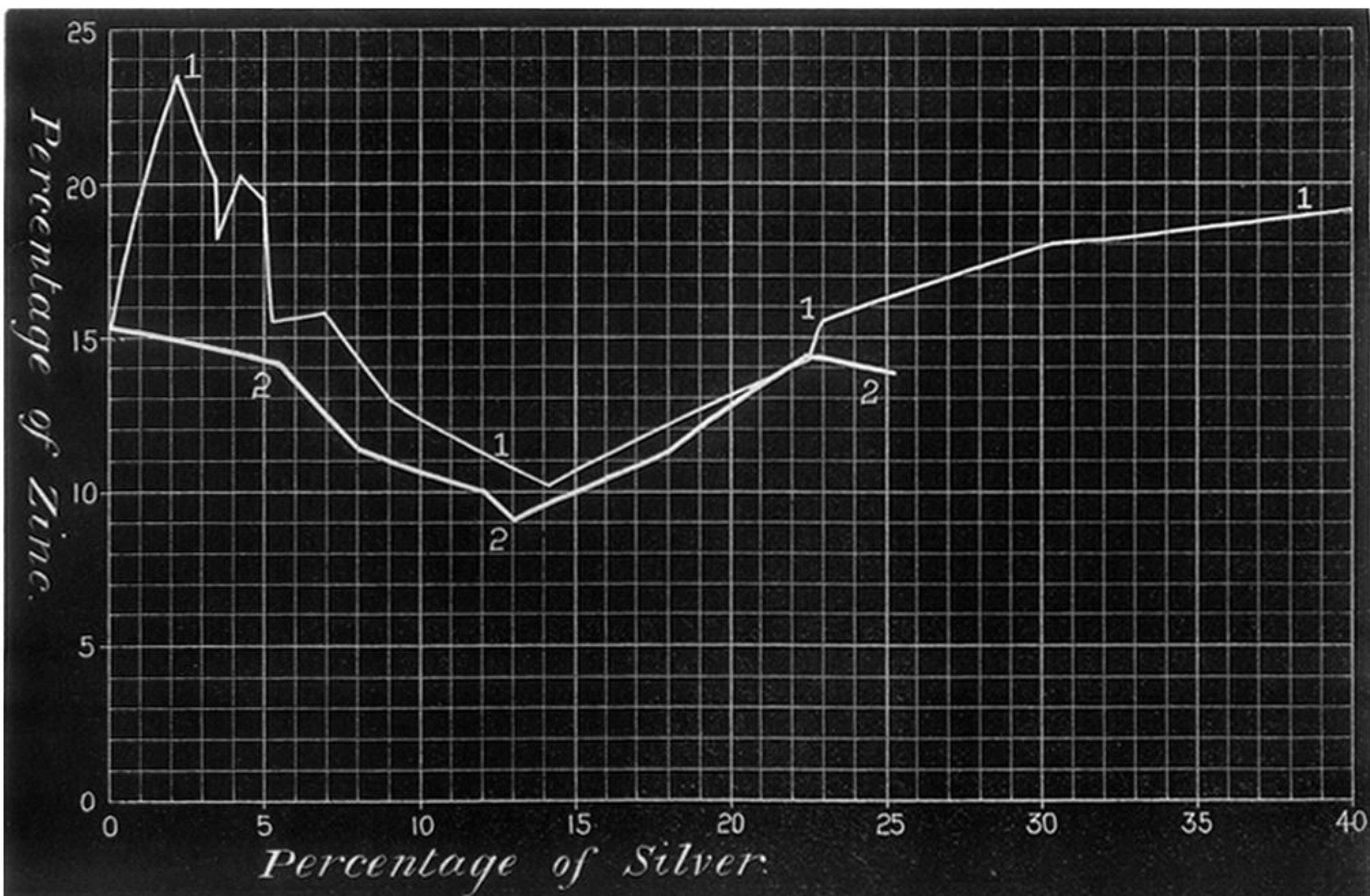


FIG. 7.

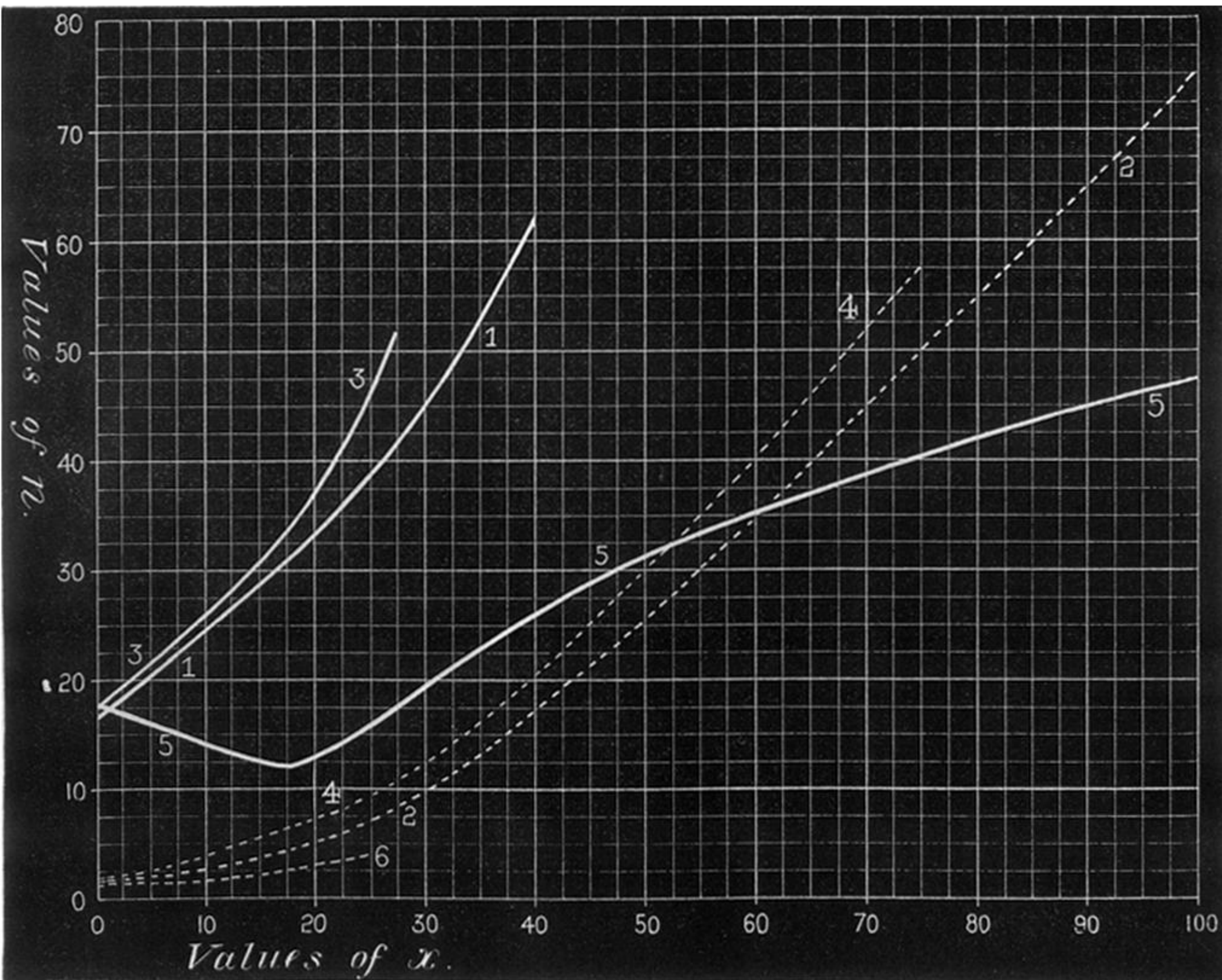


FIG. 8.

